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ABSTRACT

After six years of research in computer assisted instruction (CAI) using PLATO III, a decision was made at the University of Illinois to develop a larger system as a national CAI resource. This document describes the design specifications and problems in the development of PLATO IV, a system which is capable of accomodating up to 4,000 terminals throughout the United States. The design criteria included 1) the need for an average response time of .25 second or less; 2) an average key input rate per terminal of .5 key per second; 3) 10 percent of the connected terminals would be requiring output at all times; 4) a central memory requirement of 500 words per terminal; 5) a maximum student terminal cost of $5,000; 6) a student terminal that would be reliable and simple to operate at remote locations by relatively unsophisticated users; 7) the development of a system that would be manageable by a relatively small staff; and 8) a hardware system architecture that would not inhibit the development of the software which was trailing behind the hardware development. The remainder of the document briefly describes the development and operating characteristics of PLATO IV. (Author/DGC)

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The Evolutionary Development of CAI Hardware

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After some six years of CAI research using the PLATO III system, a decision was made in 1966 to develop a much larger system which could better provide the facilities for evaluating CAI concepts. Whereas PLATO III was a small system containing only 20 student terminals attached to a computer in the same building, PLATO IV would contain as many as 4,000 terminals which would be remotely located throughout the United States. While PLATO III utilized student terminals containing CRT (cathode ray tube) displays, similar to the picture tubes in television receivers, PLATO IV would use a new display technology called the plasma panel. Briefly described, this device is a transparent flat sandwich of glass plates in which the computer can write information and on the rear of which images from a slide projector can be displayed. Such a technique allows the superposition of computer-generated information on locally stored slide information.

The challenge was to design a system containing a computer, up to 4,000 student terminals, and a communication network to connect the latter to the former.

From an engineering point of view, the experience gained from the PLATO III system provided a minimum of specifications on which to base the design of PLATO IV. This was so primarily because of the different technology involved and the local nature and small size of PLATO III as compared to the large size and remote terminal deployment to be used in PLATO IV. There were, however, four critical parameters derived from PLATO III which would heavily influence the design of PLATO IV. These were:

1. the need for an average response time of .25 second or less.
2. an average key input rate per terminal of .5 key per second.
3. that 10% of the connected terminals would be requiring output at all times.
4. a central memory requirement of 500 words per terminal.

Added to the above were the following design goals:

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5. a maximum student terminal cost of $5,000.
6. a student terminal that would be reliable and simple to operate at remote locations by relatively unsophisticated users, i.e., personnel not experienced in the use of computer technology.
7. the development of a system that would be manageable by a relatively small staff.
8. a hardware system architecture that would not inhibit the development of the software which was trailing behind the hardware development.

Armed with the above information, the design of PLATO IV was launched. Little was known at the time about the plasma panel characteristics other than in the future one would exist. At that time only postage-stamp-sized versions existed. The minimum allowable resolution was determined by making drawings of characters using a dot format and then photographically reducing them to sizes corresponding to 40, 50, and 60 dots per inch. From this rather crude simulation, a minimum resolution of 50 dots per inch was established. (Fortunately, industry was able to produce a panel containing 60 dots per inch). A screen size of approximately 10" on a side was desired requiring, therefore, at least 500 lines of dots. The actual number of lines used was 512 since this is easily addressed using binary information ($512 = 2^9$).

To attempt to design a computer terminal whose characteristics would present few limitations to any potential user and keep the cost reasonable would appear to be a formidable task. However, by recognizing at the outset the impossibility of trying to anticipate all possible future applications and concentrating instead on the basic nature of information display a practical design was developed.

All forms of information display are actually composed of many dots arranged into an easily recognized pattern. Therefore, by providing the ability to display single dots, it is possible to construct all possible displays. Unfortunately, while this is the most basic form of displaying information, it is also the slowest since the address of each dot must be supplied to the terminal. By observing that all objects can also be drawn using line segments (lines of dots) it is possible to overcome the above mentioned speed limitation. Using this technique only the two end points of the line need to be specified, the terminal can perform the necessary calculations to generate the points required to draw the line. A third widely used form of information display is a set of standard patterns of dots commonly known as alphanumeric characters. Using this form of display,

only a pattern identifier need be supplied to the terminal. The terminal then displays the dots in that particular pattern. In the case of the PLATO IV terminal, only six bits of information are required to display up to 128 dots in one of these patterns.

The PLATO IV terminal contains only these three modes of display data, single points, lines, and characters (patterns), the latter two of which are locally generated. In the case of characters, the terminal contains a fixed set of 126 of the most commonly used English alphanumber characters. These include upper and lower case alpha characters, numbers 0-9, standard punctuation set, and some commonly used mathematical symbols. A very important feature of the PLATO IV terminal is the inclusion of a second set of 126 characters, the patterns of which are not fixed, but are specified by the user. Although this alterable character set was included to permit use of various foreign alphanumerics, it became an even more powerful feature when used to display graphic information. Examples of this type of use are shown in Figure 1. The use of this character set also makes possible a limited form of animated display.

Other features included in the terminal are the ability to operate unspecified external devices which might be encountered in laboratory experiments and the use of an automatic yet simple technique for recovering from transmission errors. Often the error recovery occurs so quickly that the operator observes no effects of the error.

As alluded to earlier, the use of local character and line generation maximizes the amount of information displayed per bit of information supplied to the terminal. These features permit the terminal to be operated over low band width facilities such as telephone circuits and still be able to generate complex graphical displays reasonably fast. To further improve the information display/bandwidth rates, a unique data format was developed for use in PLATO IV. Whereas the standard ASCII (American Standard Code for Information Interchange) would require 25% - 40% overhead (information which must be transmitted for control purposes but which is not displayed), the PLATO data format contains only 10% overhead.

The design of the PLATO IV communication network posed somewhat different problems from the terminal design. Here the .25 second response time requirement dictated the design. Because all keys generated at the terminal keyboard must be transmitted to the computer, processed, and then returned

to the terminal before they are displayed, there is little delay that can be tolerated in the communication network. Thus, there can be no "store and forward" equipment in the network where messages may be temporarily stored until communication conflicts can be resolved. There must be a communications "pipe" available at all times between each terminal and the computer center. Only then can data race from the terminal down the "pipe" to the computer and back again, incurring no delay and leaving each terminal user with the impression that he has the entire computer facility available to himself.

The communication network had to be defined as a set of functional modules which could be added as the system grew. The network had to present a simple interface to the computer. There would be no time available for exchanging protocals or "handshaking" between the computer and the network. The computer should be able to pour data into the network and drain data from it as fast as it arrives.

The network designed for PLATO IV contains only two types of modules, one called a Network Interface Unit (NIU) and the other called a Site Controller. One NIU and 32 Site Controllers comprise a network capable of servicing 1,000 terminals. The NIU interfaces the computer to a network of up to 32 Site Controllers each of which can service up to 32 terminals.

The NIU was designed to provide distribution of the PLATO information over conventional CATV (cable television) facilities which anticipated the future growth of this kind of service. The Site Controllers were designed to service terminals in the same locality or at locations thousands of miles away. Although the Site Controllers originally serviced only one terminal per telephone circuit, as the system grew, modems were added which combined the output of 4 ports on a Site Controller and allowed 4 terminals to be operated on one telephone circuit. The addition of this latter class of service required no basic change in the design of the Site Contoller, thereby testifying to the flexibility of the original design. In addition, even though the proportion of active terminals in PLATO IV increased to 20% from 10% in PLATO III, the communication network handled the increased load without degrading the system performance. In fact, if all 1,000 terminals were generating data at five times the rate observed in PLATO III (2.5 keys per second), the network would still deliver every key to the computer.

In terms of manageability, PLATO III required 1 technician for every 5 to 8 terminals while PLATO IV requires only 1 technician for every 80

terminals.

At the time of this writing (March, 1975), there are approximately 850 PLATO IV terminals in operation in the PLATO IV system, many performing tasks not even remotely anticipated when the terminal was designed.

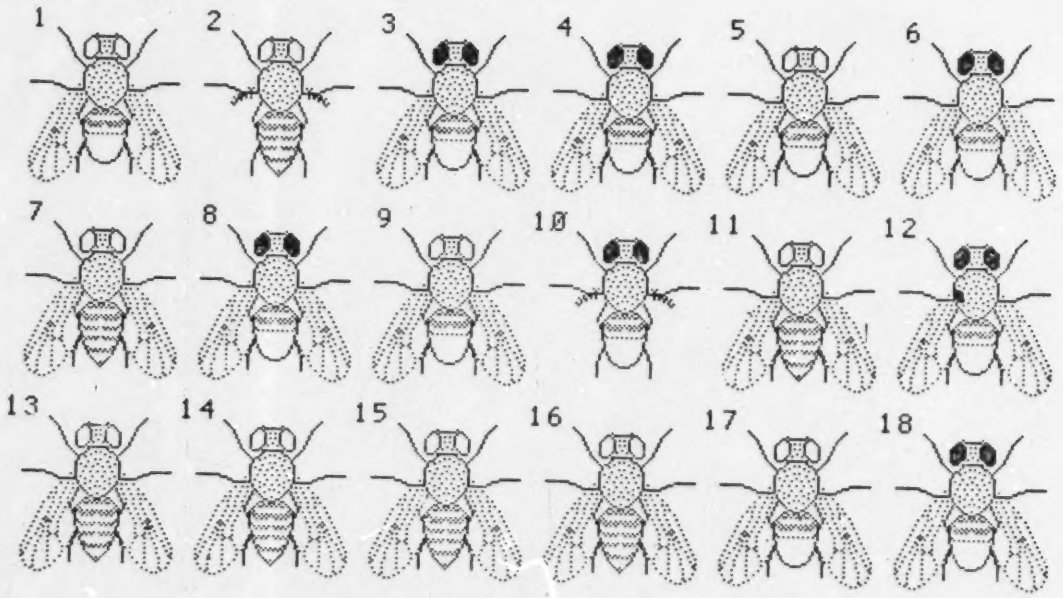
САМЕЦ

ИВАН

САМКА

НАТАША

ПОТОМСТВО



ЕСЛИ ДЛЯ СЛЕДУЮЩИХ ОПЫТОВ ВЫ ХОТИТЕ СОХРАНИТЬ,
КАКИХ-НИБУДЬ ИЗ ЭТИХ ОСОБЕЙ, ТО Я ИХ ДЛЯ ВАС СОХРАНЮ.
КАКАЯ БУДЕТ ВАША КОМАНДА ДЛЯ СЛЕДУЮЩЕГО ЭТАПА?

Figure 1. This figure is a direct copy from a PLATO IV display showing both standard and loadable characters.